FRG Workshop in Cambridge MA, May 18-19 2011

Programme

Wednesday May 18	
09:00 – 09:10	(welcoming)
09:10 – 09:50	Bachmann
09:55 – 10:35	Sims
10:55 – 11:35	Borovyk
11:40 – 12:20	Bravyi
14:10 – 14:50	Datta
14:55 – 15:35	Islambekov
15:55 – 16:35	King
16:40 – 17:20	Knowles

Thursday May 19	
09:00 – 09:40	Michalakis
09:50 – 10:30	Nachtergaele
10:50 – 11:30	Rey-Bellet
11:40 – 12:20	Schuch
14:30 – 15:10	Starr
15:20 – 16:00	Stolz
16:20 – 17:00	Vershynina

Location

Room 507 (5th floor) in the Harvard Science Center, Department of Mathematics (One Oxford Street, Cambridge MA 02138).

The Science Center is located just north of Harvard Yard (Red Line T stop: Harvard Square). The department doors are open from 9 am to 5 pm.

Abstracts

Sven Bachmann: *Local perturbations perturb locally*

We consider a quantum lattice system whose dynamics satisfies a locality property given by a Lieb-Robinson bound. For states with spectral support in an isolated part of the energy spectrum, we show that the effect of local perturbations of the Hamiltonian remains local as long as the spectrum remains gapped. A key ingredient in the proof is an explicit flow relating isolated spectral subspaces of a smooth family of Hamiltonians. Further applications of this spectral flow will be mentioned.

Vita Borovyk: *Dispersive estimates for harmonic oscillator systems*

We consider infinite-volume harmonic quantum lattice systems and study the decay of certain time-evolved observables in the large-time regime.

Sergey Bravyi: *On the energy landscape of 3D spin Hamiltonians with topological order*

We explore feasibility of a quantum self-correcting memory based on 3D spin Hamiltonians with topological quantum order in which thermal diffusion of topological defects is suppressed by macroscopic energy barriers. To this end we characterize the energy landscape of stabilizer code Hamiltonians with local bounded-strength interactions which have a topologically ordered ground state but do not have string-like logical operators. We prove that any sequence of local errors mapping a ground state of such Hamiltonian to an orthogonal ground state must cross an energy barrier growing at least as a logarithm of the lattice size. Our bound on the energy barrier is shown to be tight up to a constant factor for one particular 3D spin Hamiltonian. This is a joint work with Jeongwan Haah (Caltech)

Umar Islambekov: *A Lieb-Robinson bound for the Toda system*

We prove a Lieb-Robinson bound for the Toda system and a Lieb-Robinson type bound for a specific class of perturbations of the Toda Hamiltonian.

Nilanajana Datta: *Generalized relative entropies, entanglement monotones and a family of one-shot quantum protocols*

We introduce two generalized relative entropies which act as parent quantities for optimal one-shot rates of various information-processing tasks, which can be structured into a family tree within the resource framework of Quantum Information Theory. Moreover, they lead us to define entanglement monotones which have interesting operational interpretations.

Christopher King: *A microscopic model for resonant energy transfer between molecules*

Förster's theory of resonant energy transfer (FRET) accurately predicts the strength and range of exciton transport between separated molecules. We introduce a microscopic model for FRET which reproduces Förster's results as well as incorporating quantum coherence effects. As an application the model is used to analyze a system composed of quantum dots and the protein bacteriorhodopsin. (Joint work with B. Barbiellini, D. Moser and V. Renugopalakrishnan.)

Antti Knowles: *Spectral statistics of Erdős-Rényi graphs*

We consider the ensemble of adjacency matrices of Erdős-Rényi random graphs, i.e. graphs on N vertices where every edge is chosen independently and with probability $p \equiv p(N)$. We rescale the matrix so that its bulk eigenvalues are of order one. We prove that, as long as $pN \to \infty$ (with a speed at least logarithmic in N), the density of eigenvalues of the Erdős-Rényi ensemble is given by the Wigner semicircle law for spectral windows of length larger than N^{-1} (up to logarithmic corrections). As a consequence, all eigenvectors are proved to be completely delocalized in the sense that the ℓ^{∞}-norms of the ℓ^2-normalized eigenvectors are at most of order $N^{-1/2}$ with a very high probability.

In addition, under the assumption $pN \gg N^{2/3}$, we prove the universality of eigenvalue distributions both in the bulk and at the edge of the spectrum. More precisely, we prove (1) that the eigenvalue spacing of the Erdős-Rényi graph in the bulk of the spectrum has the same distribution as that of the Gaussian orthogonal ensemble; and (2) that the second largest eigenvalue of the Erdős-Rényi graph has the same distribution as the largest eigenvalue of the Gaussian orthogonal ensemble.

As an application of our method, we prove the bulk universality of generalized Wigner matrices under the assumption that the matrix entries have at least $4+\varepsilon$ moments. (Joint work with László Erdős, Horng-Tzer Yau and Jun Yin.)

Spyridon Michalakis: *Stability of frustration free systems*

We prove stability of the spectral gap for gapped, frustration-free Hamiltonians under general, quasi-local perturbations. We introduce a necessary and sufficient condition for stability, which we term "Local Topological Quantum Order" (Local-TQO). This result extends previous work by Bravyi et. al. on the stability of topological quantum order for Hamiltonians composed of commuting projections with a common zero-energy subspace. If time permits, I will discuss a possible path to removing the frustration-free condition altogether towards a proof of stability for gapped Hamiltonians satisfying some version of Local-TQO.

Bruno Nachtergaele: *Frustration-free ground states of quantum spin chains*

Much of what we know about the ground states of quantum spin Hamiltonians is derived from the exact solutions that can be found for two special classes of models: the Bethe Ansatz solvable models and the class of models with frustration free ground states. In this talk I will review recent work aimed at a qualitative theory of gapped ground state phases of quantum spin systems with the aid of the class of frustration free models.

Luc Rey-Bellet: *Large deviations in quantum spin systems*

We discuss recent results on the fluctuations of quantum spin systems: (a) a non-commutative version of Varadhan's lemma (joint with De Roeck, Maes and Netockny) and (b) a simple proof of the large deviations principle in 1 dimension (joint with Ogata).

Norbert Schuch: *Classifying quantum phases using matrix product states and PEPS*

We apply the framework of Matrix Product States (MPS) and their parent Hamiltonians to the classification of gapped quantum phases in one-dimensional systems and beyond. We discuss both the case of systems with unique ground states and with degenerate ground states, i.e., symmetry breaking, both in the absence and in the presence of symmetries. We find that without symmetries, all systems (up to ground state degeneracy) are in the same phase. If symmetries are imposed, the classification is based on the different types of projective representations of the symmetry group, together with its permutation action on the symmetry broken ground states. We also discuss how to extend our results to two dimensional systems using Projected Entangled Pair States (PEPS), and show that one cannot expect the same type of symmetry protection as in one-dimension. As a central tool, we introduce the isometric form of an MPS which gives a rigorous framework for studying phases using renormalization fixed points, without a need to actually renormalize the system. (Join work with D. Perez-Garcia and I. Cirac.)

Robert Sims: *Automorphic equivalence within gapped phases*

We consider a family of short range, quantum spin Hamiltonians $H(s)$ depending smoothly on a parameter s in $[0,1]$. If $H(s)$ has a uniform, non-vanishing spectral gap, then we construct an automorphism, which we call the spectral flow, and show that it satisfies a variety of useful estimates. The existence of this spectral flow demonstrates that the ground state phase structure is preserved along this curve of models, i.e., $H(s)$ for s in $[0,1]$.

Shannon Starr: *Ferromagnetic quantum spin chains with* $\mathrm{SU}_q(2)$ *symmetry*

We consider conditions for spin chains with $\mathrm{SU}_q(2)$ symmetry to behave "ferromagnetically" meaning that the ground state is the maximal multiplet, and the minimal energies of the other multiplets are ferromagnetically ordered. Among the examples we consider, some have interesting behavior such as an extensive ground state entropy. This is joint work with Bruno Nachtergaele and Stephen Ng.

Gunter Stolz: *Dynamical localization in the disordered xy-spin chain*

We will show that a quantum xy-spin chain which is exposed to a random exterior magnetic field satisfies a zero-velocity Lieb-Robinson bound. This can be interpreted as dynamical localization for the spin chain or as absence of information transport. We will also discuss a general result, which says that zero velocity LR-bounds in a quantum spin system imply exponential decay of ground state correlations. This is joint work with Robert Sims and Eman Hamza and motivated by recent works of Burrell-Osborne as well as Hastings.

Anna Vershynina: *Lieb-Robinson bounds and existence of thermodynamic limit for a class of irreversible quantum dynamics*

We consider a class of irreversible dynamics for quantum lattice systems with time dependent generators that are sums of Hamiltonian and dissipative terms that satisfy a suitable decay condition in space. For such models we prove Lieb-Robinson bounds and show the existence of the thermodynamic limit of the dynamics in the sense of a strongly continuous cocycle of unit preserving completely positive maps. (Join work with B. Nachtergaele and V. Zagrebnov.)